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DEVELOPMENT OF A JOB-RELATED PHYSICAL PERFORMANCE EXAMINATION FOR FIREFIGHTERS

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A SUMMARY REPORT

federal emergency management agency
U.S. fire administration

DEVELOPMENT OF A JOB-RELATED PHYSICAL PERFORMANCE EXAMINATION FOR FIREFIGHTERS

A SUMMARY REPORT

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Prepared for

Federal Emergency Management Agency
U.S. Fire Administration
National Fire Data Center

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FORWORD

Any opinions, findings, conclusions or recommendations expressed in this publication do not necessarily reflect the views of the Federal Emergency Management Agency or the U.S. Fire Administration.

EXECUTIVE SUMMARY

The purpose of this study was to determine the relations between firefighting ability and selected physical characteristics of firefighters. Based on laboratory and field experiments, a series of tests was developed for predicting the probability of successful and efficient performance as a firefighter.

One hundred professional firefighters, serving as subjects were randomly selected from the population of Metropolitan Washington, D.C. firefighters, according to age and jurisdiction. All subjects were screened for cardiovascular disease through EKG tests at the Sports Medicine and Physical Fitness Center of the University of Maryland.

The first phase of performance tests was conducted in this laboratory: push-ups, sit-ups, chin-ups, standing broad jump, grip strength, flexibility tests, oxygen consumption tests, and blood pressure responses. The second phase of the testing was conducted at the University of Maryland's Fire/Rescue Institute Training Academy. Performance was measured while each firefighter was wearing full turnout gear and breathing apparatus. Each firefighter performed selected criterion tasks as expeditiously as possible, replicating actual fire scene activity. The firefighting evolutions were as follows: 1. Ladder work; 2. Standpipe section carry; 3. Hose pull with rope; 4. Simulated rescue carry; and, 5. Simulated chopping.

A total of 26 physical performance variables was assessed and correlated against timed measures of the five simulated firefighting tasks performed in sequence and the fractionated heart rate data. Correlation analysis of the data identified key variables relating physical performance and simulated firefighting.

Heart rate responses to field testing indicate that the seven-minute average completion time requires approximately 90% of the firefighters physical work capacity. Age limits performance, intimating that the older firefighters are working at a higher percentage of their functional work capacity. From the data analysis it was determined that there were two primary factors operating in the simulated firefighting activities: high aerobic energy involvement and resistance to fatigue. The physical performance variables best predicting high aerobic energy involvement included maximal heart rate, sit-ups, grip strength, age and submaximal oxygen pulse. The physical performance variables best predicting resistance to fatigue included lean body weight, maximal heart rate, final treadmill grade, age and percent fat. It was concluded that the successful completion of firefighting tasks requires a physical performance profile reflecting youth, high aerobic capacity, high muscular strength and endurance, above average lean body weight and minimal body fat.

A field test scoring formula, of somewhat less accuracy than those used in these experiments was developed to screen firefighters for physical performance limitations.

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Background

There exists in the Fire Service a confusing number of entry level physical performance examinations with major differences in both their development and implementation. Some of the examinations were simply nominated by individual Fire Departments because they seemed like appropriate tests. Other departments have used more scientific methods, including task analysis to delineate the occupation of firefighting into basic physical components such as strength, flexibility and stamina. Of late, there has been a great interest in the methodology and the final products of these tests on the part of minority groups and the courts.

The Sports Medicine and Physical Fitness Center of the University of Maryland was awarded a grant from the National Fire Prevention and Control Administration for the purpose of quantifying the physiological and physical requirements of the structural firefighter. Information derived from this study was then to be used to develop a physical performance entrance level examination for firefighters. Thought was also to be given concerning recommendations for implementation of health and fitness maintenance and preventive measures knowing that a Fire Service suffers from the highest incidence of cardiovascular disease than any other occupation.

Methodology

This study differed from other task analysis studies in that the actual act of firefighting was studied empirically, rather than subjectively, drawing inferences about what components were operating during the

course of firefighting. A number of representative firefighting tasks were needed for the purpose of the study. The Fire Training Officers of the Metropolitan Council of Governments - Washington, D.C. nominated representative firefighting tasks. The tasks nominated met one or more of the following criteria: (1) frequently performed, (2) critical in nature, (3) physiologically stressful, (4) quantifiable in terms of time for completion and (5) required minimal instruction. The committee submitted a list of eleven firefighting tasks of which five were selected for use in field testing. These nominated tasks were compared against a task analysis compiled from the District of Columbia and found to be an excellent representation. These tasks will be expanded upon later.

The next step in the study called for the selection of 100 career firefighters from the seven jurisdictions comprising the Council of Government Area. Lists of all active fire suppression personnel and their ages were obtained from the local fire departments. From these data, the distribution of career firefighters classified by age and department was constructed. (See figures 1 and 2) The final 100 participants reflected the firefighter population of the City of Alexandria, Arlington County, and Fairfax County, Virginia; the District of Columbia; Prince Georges County and Montgomery County, Maryland. Since the District of Columbia comprised 40% of the total population, they were represented by 40 personnel in the study whose ages reflected the demographic makeup of their department. This same format was followed for all other departments. Montgomery County's 16 independent fire departments were collectively combined for the purpose of this study. The Montgomery County's Department of Fire/Rescue Service was not included as

a part of the population or sample. It was important that all participants be selected at random. For this purpose, a random number generator program was used. The random number was then matched against a list for the selection of the appropriate person. Selected individuals were then mailed a personally addressed letter stating that they had been selected for participation in the study and requesting their informed consent and agreement to participate in the study. Of the original 100 selected, 74 completed all phases of the testing. Twenty-six additional individuals were randomly selected to replace those who could not or would not participate (See chart 3 for reasons for refusal). Virtually all of the departments provided released time for their men to be tested, insuring liability coverage in the event an accident or injury occurred while participating in the study.

The testing was divided into two parts, a laboratory test session at the Sports Medicine and Physical Fitness Center which included the assessment of physiological performance parameters, physical performance measurements and medical tests to insure that all participants were medically sound. The second test session was conducted at the University of Maryland's Fire/Rescue Institute Fire Training Academy.

The first test session (laboratory) included the following test items in sequence: resting 12 lead EKG, height and weight (figure 1), anthropometric measurements (figures 2 and 3), resting blood pressure (figure 4), grip strength (figure 5), and U.S. Forest Service firefighter step test (figure 6). Following these tests, six of the seven National Fire Protection Association (NFPA) 1001 physical performance tests were administered along with the Wells and Dillon flexibility test (figure 11) and standing broad jump (figure 13). The NFPA 1001 physical performance test administered

during the first session included push-ups and sit-ups (figure 8), chin-ups (figure 7), flexibility test (figure 10), balance beam (figure 9), 125 lb. weight carry (figure 12. A description of these test items is included in the appendix. The last item administered during the first laboratory visit was a graded exercise stress test (figure 14). In this test, each subject was monitored via the application of a V_5 electrode configuration while walking on a motor-driven treadmill. The first stage of the test consisted of walking on a treadmill at a speed of 3.4 mph at a grade of 6% for a period of four minutes. During this work stage, heart rate, expired air, blood pressure measurements and oxygen consumption expressed in liters per minute and milliliters per kilogram of body weight per minute were obtained. Ventilatory equivalence (the ratio of air breathed to the amount of oxygen used) and oxygen pulse (the amount of oxygen consumed per heart beat) was determined through transgeneration of the original data. After four minutes of walking at the 6% elevation, the treadmill grade was increased an additional 2%, and continued to be increased 2% at the end of every two minutes, until the firefighter could not continue. A Beckman Metabolic Measurement Cart was used to monitor respiratory parameters during each minute of exercise. The purpose of this phase of the stress test was to determine maximum heart rate, maximum oxygen consumption, and maximum breathing capacity under extremely heavy work conditions, as well as any cardiac abnormalities which sometimes appear under these conditions. The stress EKG is approximately 85-95% effective in determining the presence of coronary artery disease (CAD). Seven of the firefighters tested showed abnormal beats during testing, none had abnormal resting EKG's. All EKG's were reviewed by the Center's cardiologist.

All firefighters were furnished with copies of their EKG's or had them forwarded to their personal physician upon written authorization. Upon completion of the first test session, each firefighter was asked to select a date for his visit to the Academy for field testing. A written explanation of the second phase of the test was provided and he was asked to bring his own fire fighting equipment with him.

At the second test session (fire academy) each firefighter was given instructions, via a tape recording, for the simulated firefighting tasks. All the tasks were to be performed wearing full turnout gear; i.e. helmet, coat, boots, and demand breathing apparatus. One MSA demand type breathing apparatus was used for all subjects. The regulator was calibrated before the field testing began, was checked once again after the testing, and was found to be within recommended specifications. A test gauge was also used to accurately determine the pressure of the gas cylinders both before and after use (figure 17). Only one cylinder per person was used for each of the test sessions. During the field test, each firefighter was connected to a miniature EKG recording device (figure 15). This device continuously recorded the firefighter's electrocardiogram throughout the entire test session. Two leads were used for each subject to ensure that should one channel be lost there would still exist a backup.

The five field tasks performed sequentially were as follows: walk to a 35 foot extention ladder which was lashed to the fire escape at the side of the five story fire training tower, extend the fly section of the ladder, engage the dogs, and finally retrace the ladder without allowing the rope to slip through the hands (figure 18). The time recorded for this event ended when the fly section of the ladder touched the pavement.

Times were also similarly recorded for each of the subsequent field events as well as the total elasped times for all five field events. Immediately upon completion of the ladder extention, the second task was begun. This task entailed the carrying of a 73 pound stand-pipe hose load to the fifth floor of the training academy (figure 19). The load consisted of: 150 feet of one and one-half inch hose with nozzle, a spanner wrench and a two and one-half inch adapter. At the top of the stairs, the stand-pipe was deposited on the floor in an appropriately marked space to complete the second task. The third task required the firefighter to pull a section of 2-½" hose, including brass couplings (52 lbs.), aided by a hose roller and a one-half inch utility line, to the fifth floor window (figure 20). The time for the completion of this task was recorded when the coupling cleared the window sill. The fourth task was a simulated rescue. A 117 lb. dummy was either carried or dragged from the fifth floor to the exterior of the building (figure 21). This task was completed when the dummy cleared the starting line on the outside of the building. The final task was a simulated forcible entry. In this task, the firefighter, using an eight pound sledge hammer, struck a railroad-tie for a total of 30 swings, generating as much force as possible. Two timing gates were set up through which the sledge was to pass, giving the velocity of the head of the sledge from which force could be calculated (figure 22). At the completion of this task, the total time was recorded and the breathing apparatus was disconnected. Each firefighter was asked to rest for whatever period of time was necessary before completing the last item in NFPA 1001 physical performance test battery, the 12 minute run test.

The twelve minute run test was administered on a ¼ mile running track. The track was marked off in one-tenth increments through the use of traffic

cones. Each firefighter was asked to run as far as he could, for twelve minutes, and at the sound of the whistle, walk to the nearest traffic cone. The distance in miles was then determined from the number of laps and tenths thereof. This completed all testing.

RESULTS

A. Descriptive Statistics

A stratified random sample of 100 professional firefighters from Metropolitan Washington, D.C. served as subjects. The stratification was by age and jurisdiction. The profile of the sample by age and jurisdiction is presented in Table 2. Since the sample generated did not allow for definitive analysis of the data by age or jurisdiction categories, no descriptive information is given for these strata of the sample.

Means, standard deviations, coefficients of variation, maximum and minimum values for each of the simulated firefighting tasks, and the anthropometric, physiological, muscular strength, muscular endurance, muscular power, and flexibility variables are presented in Table 4.

1. Simulated Firefighting Tasks

The mean time to complete the five simulated tasks was 7.03 minutes. The simulated rescue required the greater percentage of the total intertask time (34.1%), followed by the standpipe carry (22.6%) simulated forcible entry (21.8%), 50 ft. hose pull (13.7%), and ladder extension task (7.8%). During the performance of the five tasks, the firefighters heart rate elevated to a peak intertask mean rate of 178.53 beats per minute. This value represented 97 percent of the maximum heart rate, suggesting that at peak rates the firefighters were working at their maximum aerobic capacity.

The firefighters average heart rate for the duration of the five task assignment was 168.89 BPM, or 91.8 percent of the maximum heart rate. In addition, the firefighters mean heart rate, immediately following completion of the five tasks, was 164.6 BPM or still 89.5 percent of the maximum heart rate. It should be noted that the performance of the simulated tasks included in this study were not performed in a heated environment normally associated with firefighting. With the additional burden placed on the cardiovascular system by heat, it can be concluded that the aerobic capacity of the firefighter is not, on the average, adequate to complete typical firefighting tasks at the pace observed in this study. An inspection of heart rate curves generated from the Holter Monitor tapes revealed a typical pattern for heart rate acceleration during performance of an aerobic task. It is clear from these results that firefighting tasks of the type included in this study require near maximal aerobic efforts.

2. Anthropometric Measures

The sample population at an average age of 33.06 years exhibited a mean height of 179.69 cm. (69.56 in.) and a mean weight of 83.436 kg. (183.94 lbs.). Analysis of the body composition revealed the total body weight consisted of 17.63 kg. (21.13%) fat weight and 55.29 kg. (78.87%) lean weight. In light of the effort required to complete the simulated firefighting tasks, it may be concluded that the percent fat characteristics of the typical firefighter is unacceptably high. Since fat weight adds an additional burden to the cardiovascular system, and the aerobic effort required to perform firefighting tasks is near maximal, the typical firefighter assumes an unnecessary risk of collapse from fatigue while performing actual firefighting duties.

3. Physiological Measures

Inspection of the data assessed during the multilevel treadmill stress test revealed that the sample population possessed average to slightly above average physiological characteristics. The mean maximal heart rate of 183.99 BPM was only 3 BPM below the value predicted for their mean age. The sample population's mean ventilation capacity (V_E) of 119.52 liters per minute, resting heart rate of 66.73 BPM, and ventilatory equivalent of 39.60 liters of air per liter of oxygen uptake is very similar to measures assessed on adult males of the same age working in sedentary occupations. The subjects mean maximal oxygen consumption (VO_2) of 39.6 ml/kg/min stands at the lower limit of the category labeled good for 30-39 year old males of all ages. The twelve minute run mean value was 1.25 miles, which represents an average cardiovascular fitness level, according to norms for American males.

4. Muscular Strength, Endurance, Power and Flexibility

The sample population scored average to slightly above average on measures included in this category. Their mean grip strength of 104.55 lbs., push-ups at 18.96, and flexibility of 9.32, represent average performances for adult males. The subjects' mean chins of 5.52 and standing long jump of 75.92 inches may be judged as only fair for adult males. The subjects exhibited a mean sit-up performance of 36.88 which represents an above average value for adult males.

In light of the descriptive statistics assessed on the sample population, it is clear that the typical firefighter is, at best, average to slightly above average when compared to other adult males. The same population's most serious shortcoming is that of excess body fat. The

sample population's mean fat percentage of 21.1 represents an average excess fat weight of approximately 9.4 lbs. above that recommended for adult males. The significance of this excess fat weight is magnified when it is realized that excess fat weight functions as dead weight placing an additional burden on the cardiovascular system and a negative effect on the muscular performance papameters where one's total body weight must be moved through space. Thus we noted, for example, that the subjects' poorest performances were observed for the 12 minute run, chinning test, and standing long jump. In light of the average physiological and muscular performance characteristics possessed by the sample population, the subjects can ill afford to carry excess body fat.

B. Relationships Between Simulated Firefighting Tasks and Physical Performance Measures

The firefighters' performance of the five simulated firefighting tasks was quantified by monitoring the split times required to complete the tasks and continuous recording of the subjects' EKG via Holter monitoring. The Avionics model 660 Cardio Scanner (figure 23) was used to retrieve the heart rate information in print-out form (figure 24). From these data, split times, the total intertask time, peak, average, and final heart rates were transgenerated. Continuous monitoring of the heart rate allowed us to quantify the various performance times in terms of effort.

Since the fire tasks were performed in sequence without stopping, the data was submitted to canonical correlation analysis. With this procedure, it is possible to identify the factors functioning to account for the intertask times and efforts and to isolate the physiological, anthropometrical, and/or muscular performance characteristics that explain the isolated intertask factors.

From the analysis of the data it was determined that there were two factors operating in the simulated firefighting activities. The first dimension reflected a high aerobic energy involvement. The aerobic requirement was uniform across the fire tasks with greatest demand placed by the standpipe carry. The first dimension reflects the fact that rapid completion of the five tasks resulted in taxing the firefighters aerobic capacity to near maximal levels.

The best predictors of the first dimension were maximum heart rate achieved on the treadmill, push-ups, sit-ups, age, chins, sub-maximal oxygen pulse, maximal treadmill grade (%) achieved, percent fat and standing long jump. Maximal heart rate and treadmill grade reflect the ability to perform at high levels of work. Both variables correlated high with definitive measures of aerobic capacity, i.e., MAX V_{02}. Clearly, aerobic capacity limits the firefighters' ability to rapidly complete a sequence of physical tasks required during firefighting. The sub-maximal oxygen pulse reflects the efficiency of the oxygen transport system during steady state muscular work. This variable implies that low sub-maximal oxygen pulse measure indicate a less efficient oxygen transport system, and therefore increases the average intertask heart rate during the performance of the criterion tasks.

Age reflects the fact that maximal levels for each of the physical performance measures tended to decrease with age. Thus advancing age for the firefighter stands as a limiting factor to successful completion of firefighting tasks. This loss of performance does not follow for all cases. As a matter of interest we divided all participants into two groups based upon performance in the criterion tasks. The physical characteristics of the high fit group reflected high physiological performance characteristics

and youth, however, there were a few firefighters in their 40's who mirrored the characteristics of their youthful counterparts. One of the most striking comparisons was the body composition values. Although the high fit group had a nearly identical weight (184 lbs) to that of the lower fit group, the difference in percent body fat was greatly different (15,5 vs. 24,2).

The second operating factor, as determined by canonical correlation, is what we termed as a resistence to fatigue factor. From a practical nature, it would appear that entry into a burning building to the origin of fire can demand a great expenditure of energy, and a firefighters ability to escape, particularly while effecting a rescue, is critically dependent upon a resistance to fatigue factor. The profile suggested by laboratory predictors indicate that the firefighter must possess high aerobic capacity, an efficient cardiovascular system, and minimal negative factors associated with age and body fat.

Multiple regression analysis was employed to generate linear equations for the physical performance measures that best predicted the six criterion dimensions. Since many Fire Departments do not possess a human performance laboratory, we generated a second predictive formula for field use. Of course there exists a loss in the accuracy in the estimation of an applicants potential as a firefighter. Age has been removed from the predictive formulas, since it is a measure uncontrollable by the firefighter, but nevertheless an important predictor. The field test has the ability to screen firefighters for physical performance limitations, while the laboratory oriented equation possess the validity to predict aerobic effort sources, as well as evaluation for evidence of cardiovascular disease. Charts have been devised and are included in the appendix for the purpose of scoring firefighters. A

minimum number of 1000 points must be obtained as a passing score. The rating scale is as follows:

Score	Rating
1200 (and above)	Excellent
1134-1199	Good
1066-1133	Average
1000-1065	Fair
999 (and below)	Poor

The effectiveness of this rating formula may be seen in Table 5. It is interesting to note that there exists little variance in total height and lean weight among the five fitness classification groups. What does vary significantly is the percent fat and fat weight of the different groups. When looking at the physical performance of the men, there are significant relationships between the predictors and the total time to complete the criterion tasks. The excellent groups time is almost half that of the poor group. Although age is shown to affect performance, it does not follow in all cases. For example, a 40 year old in the excellent group had physical performance characteristics similar to those of his younger counterparts.

This report summarizes a dissertation titled: "Relationships Between Selected Physiological Performance Measures and Simulated Field Performance in Professional Firefighters" as submitted by Dr. Paul O. Davis in partial fulfillment of requirements for a Doctor of Philosophy degree from the University of Maryland.

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APPENDIX I

TABLES

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TABLE 1

WASHINGTON D.C. METROPOLITAN AREA

PROFESSIONAL FIREFIGHTER POPULATION BY JURISDICTION *

FIRE DEPT. AGES	D.C.	P.G.	MONT.	ARL.	ALEX.	FAIR.	TOTAL
16-19	0	0	0	1	1	0	2
20-24	95	44	84	21	5	105	354
25-29	229	117	130	53	31	212	772
30-34	347	97	143	53	34	147	821
35-39	288	32	75	31	42	79	547
40-44	163	13	42	33	22	46	319
45-49	66	3	20	42	15	21	167
50-54	15	1	10	9	3	18	56
55-59	4	0	3	2	1	1	11
60-64	0	0	1	0	0	0	1
TOTAL	1207	307	508 +	245	154	629	3050

* As of April, 1976

+ Data for the 16 independent fire departments

TABLE 2

DEMOGRAPHIC INFORMATION OF FIREFIGHTER SAMPLE

FIRE DEPT. AGES	D.C.	P.G.	MONT.	ARL.	ALEX.	FAIR.	TOTAL
16-19	0	0	0	0	0	0	0
20-24	3	1	3	1	0	3	11
25-29	8	4	4	2	1	6	25
30-34	11	3	5	2	1	5	27
35-39	9	1	2	1	1	3	17
40-44	5	1	1	1	1	2	11
45-49	2	0	1	1	1	1	6
50-54	1	0	0	0	0	1	2
55-59	1	0	0	0	0	0	1
60-64	0	0	0	0	0	0	0
TOTAL	40	10	16	8	5	21	100

TABLE 3

REASONS STATED FOR REFUSAL OR REPLACEMENT

	TOTAL N	N of original selection to participate	N to refuse	completed 1st part but unavail. for 2nd	sick leave	retired	back injuries	no longer in fire suppression	refused-on probation	previous comp. for injury not allowed due to	rescue squad not fire fighter	heart problem	presently ill	studying	doesn't volunteer
District of Columbia	40	26	4		4	1	2					1		1	1
Alexandria	5	5													
Arlington	8	4	2						1	1					
Fairfax	21	19				1		1							
Montgomery	16	13	1	1							1				
Prince Georges	10	7	1	1									1		
TOTALS	100	74	8	2	4	2	2	1	1	1	1	1	1	1	1

74% of original sample participated

26% were replaced

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TABLE 4

SUMMARY STATISTICS FOR SIMULATED TASKS AND PHYSICAL PERFORMANCE MEASURE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT VARIATION	MINIMUM VALUE	MAXIMAL VALUE
Age	33.06	7.63	.23	21.0	57.0
Height	69.56	2.14	.03	64.2	74.8
Weight	183.94	24.12	.13	132.9	252.2
Lean Weight	143.93	13.19	.09	111.11	179.9
Percent Body Fat	21.13	6.69	.32	7.5	37.7
Grip Strength	104.55	13.20	.13	70.0	144.2
Sit-ups	36.88	11.67	.32	16.0	67.0
Chins	5.52	3.61	.65	0.0	15.0
Push-ups	18.96	7.79	.41	4.0	40.0
Standing Long Jump	75.93	10.07	.13	48.0	96.5
Flexibility	9.32	3.60	.39	.9	17.0
Step Test	41.61	4.99	.12	32.9	58.5
Resting Systolic Blood Pressure	128.59	12.42	.10	105.0	170.0

Table 4 Continued

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT VARIATION	MINIMUM VALUE	MAXIMAL VALUE
Resting Diastolic Blood Pressure	81.11	7.67	.09	60.0	104.0
Resting Pulse Pressure	47.48	9.39	.20	27.0	86.0
Resting Heart Rate	66.73	10.05	.15	47.0	100.0
Submaximal Heart Rate	146.61	14.41	.10	109.0	187.0
Maximal Heart Rate	183.99	10.38	.06	155.0	205.0
Submaximal Minute Volume	61.21	14.24	.23	32.1	100.3
Maximal Minute Volume	119.52	21.82	.18	75.1	189.5
Submaximal Ventilatory Equivalence	29.43	5.46	.19	20.3	48.5
Maximal Ventilatory Equivalence	36.81	5.94	.16	26.0	64.5
Submaximal Oxygen Pulse	14.29	2.38	.17	9.5	22.2
Maximal Oxygen Uptake (l/min)	3.28	.55	.17	2.1	4.8
Maximal Oxygen Uptake (ml/kg/min)	39.60	6.42	.16	23.1	53.5
Maximal Oxygen Uptake (ml/kg lean/min)	50.26	7.39	.15	31.6	70.8
Maximal Oxygen Pulse	17.87	3.16	.18	11.0	25.8
Maximal Treadmill Grade	17.82	3.08	.17	10.0	24.0

Table 4 Continued

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT VARIATION	MINIMUM VALUE	MAXIMAL VALUE
Cardiovascular Fitness Score	242.54	57.46	.24	79.5	352.2
Ladder Extension (Minutes)	.55	.16	.29	.32	1.13
Standpipe Carry (Minutes)	1.59	.40	.25	1.00	4.08
Hose Extension (Minutes)	.97	.52	.54	.17	4.23
Simulated Rescue (Minutes)	2.40	.97	.41	1.21	9.13
Forcible Entry	1.53	1.55	1.01	.16	14.94
Total Time (Minutes)	7.03	2.67	.38	4.22	27.13
Average Heart Rate (BPM)	168.89	11.81	.07	125.00	190.00

TABLE 5

FITNESS GROUPS OF 100 PROFESSIONAL

FIREFIGHTERS

SAMPLE VARIABLES	N=10 EXCELLENT	N=27 GOOD	N=32 AVERAGE	N=21 FAIR	N=10 POOR
Age (years)	28.0	28.3	31.4	37.9	46.1
Height (inches)	68.9	69.3	69.3	70.0	69.8
Total Weight (lb.)	171.5	177.9	181.0	191.6	206.1
Lean Weight	145.5	145.1	143.1	141.5	146.2
% Fat	14.8	18.1	20.3	25.0	28.5
Fat Weight	26.0	32.8	37.7	50.0	59.7
Grip Strength (lbs.)	116.6	107.8	105.1	101.3	95.1
Chins	9.0	7.3	5.2	4.2	.9
Push-ups	28.3	23.3	17.7	15.0	10.2
Sit-ups	47.9	45.9	35.1	29.5	22.8
Maximum Oxygen Consumption (ml/kg/min)	45.2	43.1	39.2	35.2	34.9
Final Treadmill Grade Achieved (%)	21.6	19.6	17.6	15.5	14.8
Total Time to complete field test	5.68	5.73	6.84	7.88	10.75

Mean values for all parameters

APPENDIX II

FIGURES - TEST ITEMS & EQUIPMENT

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Figure 1. Determination of Height and Weight

Figure 2. Pectoral Skinfold Measurement

Figure 3. Wrist Diameter Measurement

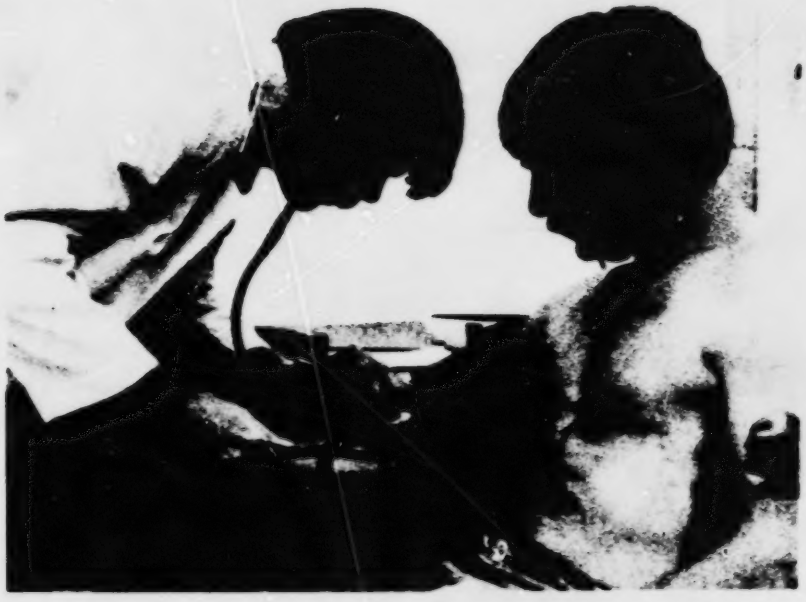

Figure 4. Blood Pressure Determination

Figure 5. Grip Strength Measurement

Figure 6. Five Minute Step Test

Figure 7. Chin-Up Test

Figure 8. Push-Up Test

Figure 9. Balance Beam and 25 lb. Weight Carry

Figure 10. NFPA 1001 Flexibility Test

Figure 11. Wells and Dillon Flexibility Test

Figure 12. 125 lb. Weight Carry

Figure 13. Standing Broad Jump Test

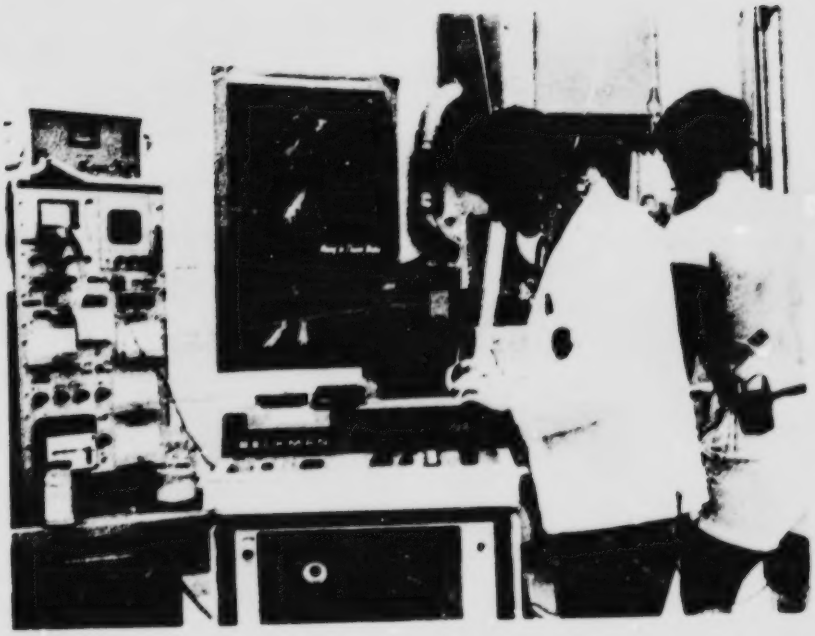

Figure 14. Dynamic EKG and Oxygen Consumption Test

Figure 15. EKG Holter Monitoring Equipment

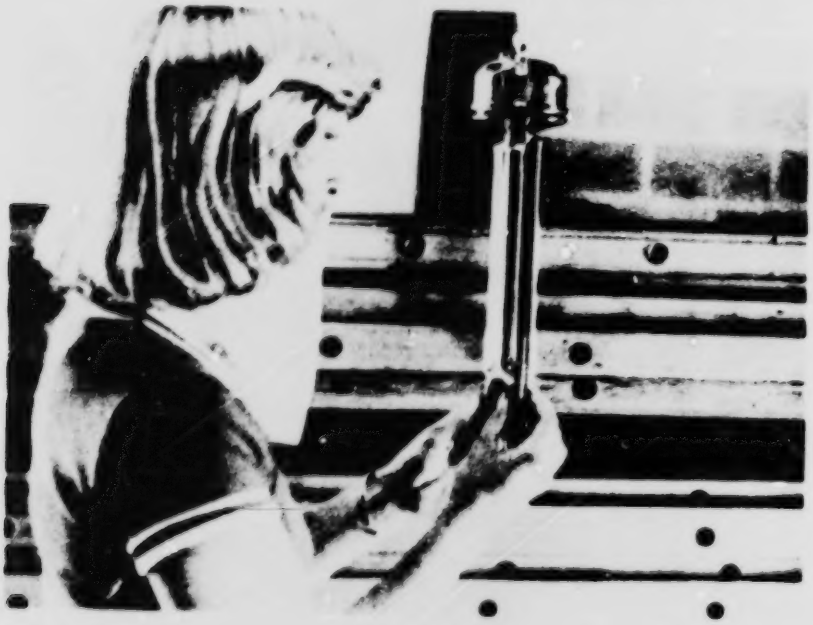

Figure 16. Determination of Relative Humidity

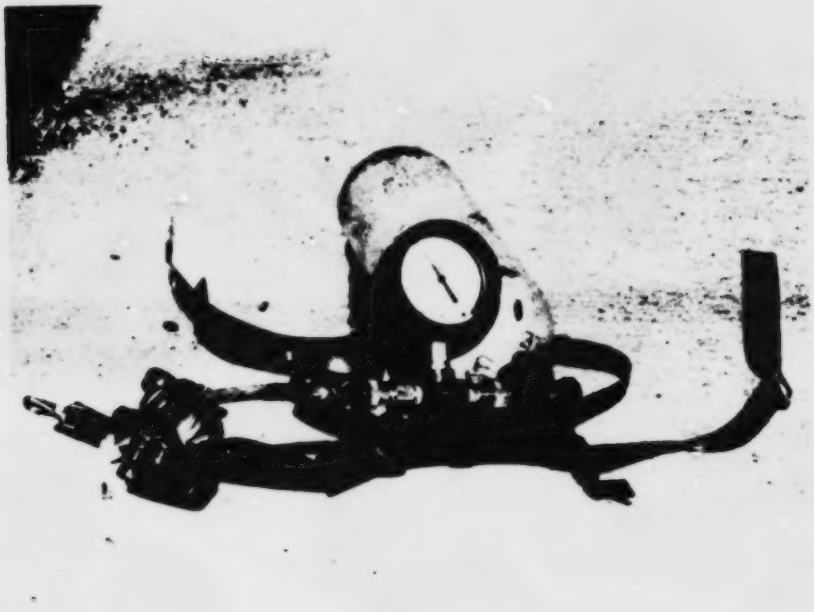

Figure 17. Breathing Apparatus Pressure Check

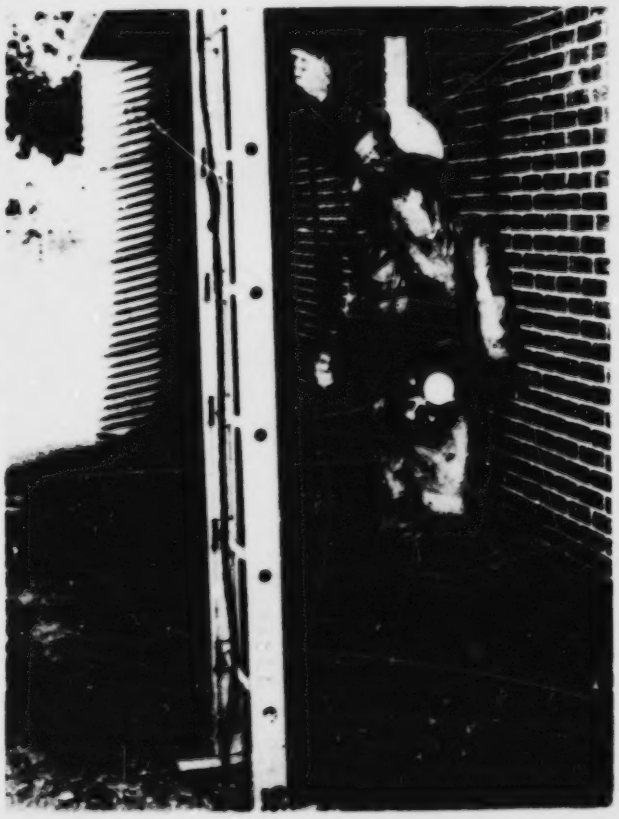

Figure 18. 35 Foot Extension Ladder Evolution

Figure 19. 73 lb. Standpipe Hose Load Carry

Figure 20. 50' - 2-1/2" Hose Pull

Figure 21. 117 lb. Dummy Drag/Carry

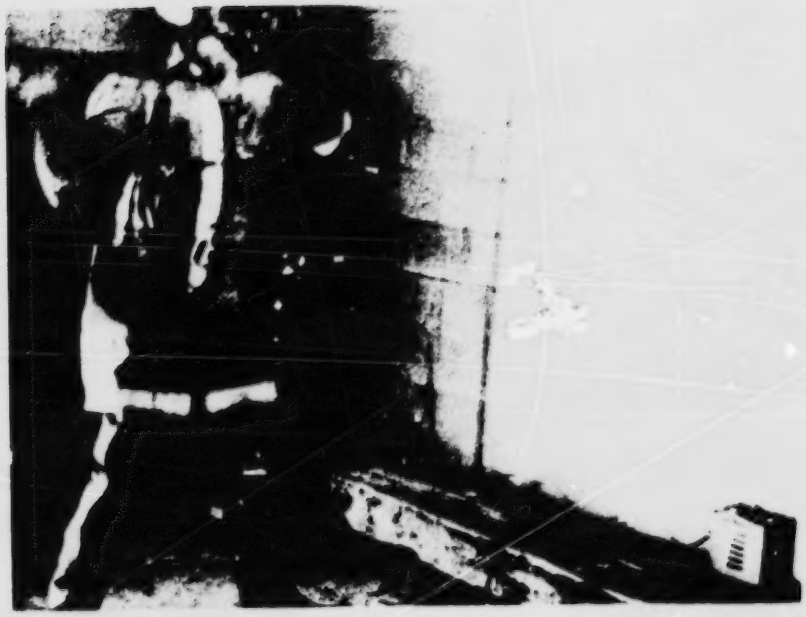

Figure 22. Simulated Chopping Exercise

Figure 23. Avionics Holter Monitor Scanner

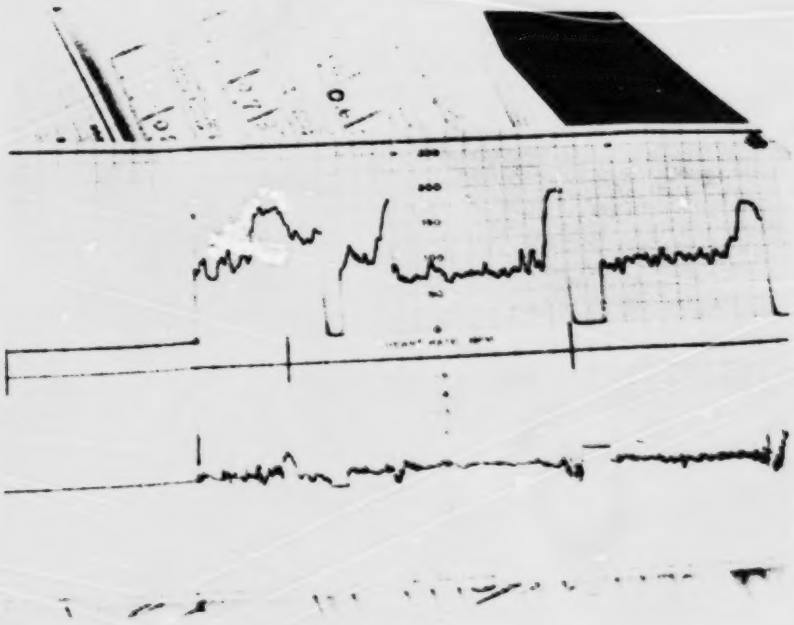

Figure 24. Heart Rate Print-Out

APPENDIX III

TEST DESCRIPTIONS

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A DESCRIPTION OF FITNESS TESTS ADMINISTERED TO ALL FIREFIGHTERS

* Asterisk denotes final test battery items

TASK: Pull-ups (figure 7)

DESCRIPTION:

The subject shall jump and grasp, with palms away, a horizontal ring set, fully extended with no body swing. This position should be maintained for at least one (1) second. The subject shall, from this position, pull the body upward, touch the chin over the lowest ring, and return to the hanging position, with arms extended, as many times as possible. (no time limit)

EQUIPMENT:

Ring set (or chinning-bar)

METHOD OF MEASUREMENT:

Each successfully completed chin-up counts as one (1).

TASK: Flexibility (from the NFPA 1001 Battery) (figure 10)

DESCRIPTION:

The subject will assume a standing position with feet approximately shoulder width apart. A fifteen (15) pound weight is placed on the floor at a point between the subject's feet. From this position the subject shall bend over, grasp the weight with both hands, lift the weight to waist level, then place the weight on the floor approximately twelve (12) inches outside the left foot, and without letting go, lift the weight to waist level and touch it to the floor approximately twelve (12) inches outside the right foot. The weight shall be moved alternately in this manner from left foot, to waist level, etc., until it has been moved seven (7) times in each direction. This shall be done in less than 35 seconds.

EQUIPMENT:

1 fifteen pound weight
Stopwatch

METHOD OF MEASUREMENT:

Can the subject perform the task? (Y, N)

TASK: Balance (figure 9)

DESCRIPTION:

The subject shall stand at one end of a beam measuring twenty (20) feet long and four (4) inches wide. Given a 25 pound weight, the subject shall walk the length of the beam carrying the weight without falling or stepping off the beam.

EQUIPMENT:

1 balance beam (20' x 4')

METHOD OF MEASUREMENT:

Can the subject perform the task? (Y, N)

*** TASK:** Push-ups (see figure #8)

DESCRIPTION:

The subject will assume a horizontal lying position, face down, with the hands placed palms down on the floor just outside and next to the shoulders. From this position the subject shall perform as many continuous push-ups as possible. The arms must be firmly extended in the "up" position and chest contact with the floor. (The examiner will place his hand on the floor under the subject, such that the subject's sternum will contact the examiner's hand upon successful completion of each push-up).

EQUIPMENT:

None needed

METHOD OF MEASUREMENT:

Total number of push-ups

* TASK: Sit-ups

DESCRIPTION:

The subject will assume a lying position on the floor with the knees bent and heels as close to the buttocks as possible. The hands should be clasped behind the head. An assistant will hold the feet against the floor. On a signal, the subject will perform as many sit-ups as possible within a 90 second period.

A sit-up shall count if, from this position, the subject brings the elbows into contact with the knees and returns to the lying position with the clasped hands in contact with the floor.

EQUIPMENT:

1 mat
Stopwatch

METHOD OF MEASUREMENT:

Each successfully completed sit-up counts as one (1).

TASK: Twelve (12) minute run

DESCRIPTION:

The subject shall run as far as possible on an outdoor track within a twelve (12) minute time period. The subject will begin on a signal and run until the signal to stop is given. At the stop signal he should stop running and remain at that point until the final lap distance can be determined.

EQUIPMENT:

Track
Stopwatch
Traffic cones

METHOD OF MEASUREMENT:

The total number plus fraction of laps completed shall be recorded and converted to total distance in miles.

* TASK: Standing long jump (figure 13)

DESCRIPTION:

The subject shall stand behind a starting line with feet parallel and jump forward with as much effort as possible. The measurement will be taken at the rear of the heels, or the part of the body closest to the standing line. Best of three attempts is recorded.

EQUIPMENT:

Measuring tape

METHOD OF MEASUREMENT:

Total inches for best jump

TASK: Weight carry (figure 12)

DESCRIPTION:

The subject shall lift a 125 pound weight and carry it 100 feet without stopping.

EQUIPMENT:

125 pound weight set

METHOD OF MEASUREMENT:

Scored Yes or No

TASK: Step Test

DESCRIPTION:

The subject shall continuously step up with each foot, and back down upon a bench or step for five minutes. The cadence for this test will be 90 counts, or 45 trips per minute, heart rate is determined within the first fifteen seconds of completion.

EQUIPMENT:

Bench, 15 3/4" tall
Metronome
Stopwatch, and Scoring Table. (see U.S. Forest Service Calculator)

METHOD OF MEASUREMENT:

Predicted oxygen consumption in ml/kg/min is taken from chart value.

NOTE: This is a predictive test; other such tests such as Astrand bicycle test or a 12 minute run field test may be substituted.

TASK: Wells and Dillon Flexibility Test (figure 11)

DESCRIPTION:

The subject shall seat himself on the floor with his feet against a platform, perpendicular to the long axis of his body. He then will slide his fingers down a ruler which runs parallel to the long axis of his body. The "zero" point is that point where the horizontal and vertical planes meet.

EQUIPMENT:

T frame and ruler

METHOD OF MEASUREMENT:

Inches $\pm$ beyond the zero point.

TASK: Grip Strength (figure 5)

DESCRIPTION: (see figure 2,3)

The subject shall exert as much force as possible against the hand dynamometer. The hand being tested must not come in contact with any surface or object. There shall be two trials per hand.

EQUIPMENT:

Jaymar hand dynamometer or equal.

METHOD OF MEASUREMENT:

Sum four trials (two per hand) and average force in pounds.

TASK: Percent Body Fat

DESCRIPTION:

Selected Anthropometric Measurements are taken: Men: Skinfold in mm. at the area of the left pectoral region. The diameter of the right wrist at the styloid process. Waist girth is measured just above the iliac crest. Women: 2 Skinfolds: Triceps, scapula, neck girth, waist circumference

EQUIPMENT:

Skinfold calipers, wrist calipers, tape measure.

METHOD OF MEASUREMENT:

Men % Fat = 8.7095+0.487303 (waist girth cms.) + 0.448561 (pectoral skinfold mm) - 6.358583 (right wrist diameter (cms)

Women: To compute lean wt:
1.661+0.668 x weight (kg) - 0.158 x scapula (mm) - .081 x triceps (mm) + 0.555 x neck circum (cm) - .141 x waist girth

$$\text{Percent Fat} = \frac{\text{Fat Wt}}{\text{Total Wt}}$$

Since the first printing of this report, the researchers have had over a year of experience in administering and utilizing the original research. As a result, the research staff has made the following suggestions:

- Passing score on the field or the laboratory-based test should represent a successful score for each of the test items. Some minimal value should be established as a floor for each test item. It is suggested that for the purpose of processing applicant firefighters, they meet, as a minimum, values attained by the Average Group in Table 5.

- Questions have been asked about the exclusion of the 12-minute run as a test item. It was the feeling of the research staff that the data derived from the 12-minute run was not consistent with known physiological principals. No doubt extraneous conditions and test sequence had an effect on the scores from this test. Since the firefighters had completed one episode of heavy work on the same day and had nothing to prove by an all-out performance on this event, their efforts on the 12-minute run did not represent a true characture of their cardio-vascular status. The validity of the 12-minute run has been established, and we feel it is appropriate for young healthy applicants.

- Minorities participating in this study (15%) did not represent a significantly different profile from the rest of the sample.

- No women were included in the study. Since there was only one female professional firefighter in the studied population, deliberatly including her would have biased random selection techniques. Her chances of being selected were the same as any firefighter, specifically 1 in 3050. While we do not have sufficient empirical data to substantiate how females would do on such a test, we do know from other physiological studies that female performance in physiological testing of this type is typically 60-70 percent that of males, on the average. More research is warranted in this area. The very nature of the research design required that incumbent firefighters be used for the quantification of effort in successfully performing firefighting duties.

- In an analysis of smokers versus non-smokers there existed some significant differences and some discriminatory trends, particularly with regard to endurance and ventilatory measurements.

- The 1000 points minimal acceptable value is based upon a standard score, one-and-a-half standard deviations below the mean.

- For those jurisdictions wishing to use an alternative or substitute test for the Step Test, the mile-and-half run for time may be used. Simply use the predicted aerobic capacity score for this event in lieu of the step test score.

APPENDIX IV

TEST SCORING PROCEDURES

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HOW TO USE THE SCORING TABLES

There are two basic types of tests used to determine the physical performance level of firefighters.

One test uses the equipment associated with a human performance laboratory, the other utilizes a field test battery.

The values for the performance tests should be read from the appropriate chart and entered in the space allocated for that parameter.

LABORATORY TEST=SCORE SHEET

		Point Value from Table
Percent Fat		_____
Lean Weight	+	_____
Max. Heart Rate	+	_____
Treadmill Grade	+	_____
Grip Strength	+	_____
Sit-ups	+	_____
Long Jump	+	_____
Oxygen Pulse, Submaximal	+	_____
Constant	+	250
Total Points		_____

FIELD PERFORMANCE TEST

		Point Value from Table
Percent Fat		_____
Lean Weight	+	_____
Step Test Score	+	_____
Push-ups	+	_____
Sit-ups	+	_____
Grip Strength	+	_____
Constant	+	460
Total Points		_____

PERCENT FAT
LABORATORY TEST VALUES

%	Pts.
4.0	59.
4.5	59.
5.0	58.
5.5	57.
6.0	56.
6.5	55.
7.0	55.
7.5	54.
8.0	53.
8.5	52.
9.0	51.
9.5	50.
10.0	50.
10.5	49.
11.0	48.
11.5	47.
12.0	46.
12.5	45.
13.0	45.
13.5	44.
14.0	43.
14.5	42.
15.0	41.
15.5	41.
16.0	40.
16.5	39.
17.0	38.
17.5	37.
18.0	36.
18.5	36.
19.0	35.
19.5	34.
20.0	33.
20.5	32.
21.0	32.
21.5	31.
22.0	30.
22.5	29.
23.0	28.
23.5	27.
24.0	27.
24.5	26.
25.0	25.
25.5	24.
26.0	23.
26.5	23.
27.0	22.
27.5	21.
28.0	20.
28.5	19.
29.0	18.
29.5	18.
30.0	17.
30.5	16.
31.0	15.
31.5	14.
32.0	14.
32.5	13.
33.0	12.
33.5	11.
34.0	10.
34.5	9.
35.0	9.
35.5	8.
36.0	7.
36.5	6.
37.0	5.
37.5	4.
38.0	4.
38.5	3.
39.0	2.
39.5	1.
40.0	0.

LEAN WEIGHT (POUNDS)
LABORATORY TEST VALUES

LBS.	PTS.
90	108.
91	109.
92	110.
93	111.
94	112.
95	114.
96	115.
97	116.
98	117.
99	118.
100	120.
101	121.
102	122.
103	123.
104	124.
105	126.
106	127.
107	128.
108	129.
109	130.
110	132.
111	133.
112	134.
113	135.
114	136.
115	138.
116	139.
117	140.
118	141.
119	142.
120	144.
121	145.
122	146.
123	147.
124	148.
125	149.
126	151.
127	152.
128	153.
129	154.
130	155.
131	157.
132	158.
133	159.
134	160.
135	161.
136	163.
137	164.
138	165.
139	166.
140	167.

LBS.	PTS.
141	169.
142	170.
143	171.
144	172.
145	173.
146	175.
147	176.
148	177.
149	178.
150	179.
151	181.
152	182.
153	183.
154	184.
155	185.
156	187.
157	188.
158	189.
159	190.
160	191.
161	193.
162	194.
163	195.
164	196.
165	197.
166	199.
167	200.
168	201.
169	202.
170	203.
171	205.
172	206.
173	207.
174	208.
175	209.
176	210.
177	212.
178	213.
179	214.
180	215.
181	216.
182	218.
183	219.
184	220.
185	221.
186	222.
187	224.
188	225.
189	226.
190	227.

MAXIMUM ATTAINABLE HEART RATE
LABORATORY TEST VALUES

HR	Pts.
160	152.
161	153.
162	154.
163	155.
164	156.
165	157.
166	158.
167	159.
168	160.
169	161.
170	161.
171	162.
172	163.
173	164.
174	165.
175	166.
176	167.
177	168.
178	169.
179	170.
180	171.
181	172.
182	173.
183	174.
184	175.
185	176.
186	177.
187	178.
188	179.
189	180.
190	180.

HR	Pts.
191	181.
192	182.
193	183.
194	184.
195	185.
196	186.
197	187.
198	188.
199	189.
200	190.
201	191.
202	192.
203	193.
204	194.
205	195.
206	196.
207	197.
208	198.
209	199.
210	199.
211	200.
212	201.
213	202.
214	203.
215	204.
216	205.
217	206.
218	207.
219	208.
220	209.

TREADMILL GRADE (%) @ 3.4 MPH
LABORATORY TEST VALUES

%	Pts.
0	0.
1	7.
2	14.
3	21.
4	28.
5	36.
6	43.
7	50.
8	57.
9	64.
10	71.
11	78.
12	85.
13	93.
14	100.
15	107.
16	114.
17	121.
18	128.
19	135.
20	142.
21	150.
22	157.
23	164.
24	171.
25	178.
26	185.
27	192.
28	199.
29	206.
30	214.

SIT-UP TEST
LABORATORY PERFORMANCE VALUES

Reps	Pts.	Reps	Pts.
0	0.	36	75.
1	2.	37	77.
2	4.	38	79.
3	6.	39	81.
4	8.	40	83.
5	10.	41	85.
6	12.	42	87.
7	15.	43	89.
8	17.	44	91.
9	19.	45	94.
10	21.	46	96.
11	23.	47	98.
12	25.	48	100.
13	27.	49	102.
14	29.	50	104.
15	31.	51	106.
16	33.	52	108.
17	35.	53	110.
18	37.	54	112.
19	40.	55	114.
20	42.	56	116.
21	44.	57	119.
22	46.	58	121.
23	48.	59	123.
24	50.	60	125.
25	52.	61	127.
26	54.	62	129.
27	56.	63	131.
28	58.	64	133.
29	60.	65	135.
30	62.	66	137.
31	64.	67	139.
32	67.	68	141.
33	69.	69	143.
34	71.	70	146.
35	73.		

STANDING LONG JUMP
LABORATORY TEST VALUES

In.	Pts.	In.	Pts.
40	48.	76	91.
41	49.	77	92.
42	50.	78	93.
43	51.	79	95.
44	53.	80	96.
45	54.	81	97.
46	55.	82	98.
47	56.	83	99.
48	57.	84	101.
49	59.	85	102.
50	60.	86	103.
51	61.	87	104.
52	62.	88	105.
53	63.	89	107.
54	65.	90	108.
55	66.	91	109.
56	67.	92	110.
57	68.	93	111.
58	69.	94	113.
59	71.	95	114.
60	72.	96	115.
61	73.	97	116.
62	74.	98	117.
63	75.	99	119.
64	77.	100	120.
65	78.	101	121.
66	79.	102	122.
67	80.	103	123.
68	81.	104	124.
69	83.	105	126.
70	84.	106	127.
71	85.	107	128.
72	86.	108	129.
73	87.	109	130.
74	89.	110	132.
75	90.		

OXYGEN PULSE (ML/BEAT)
LABORATORY TEST VALUES

(Submaximal Work Load,
6% grade, 3.4 mph)

Score	Pts.
4.00	119.
4.25	117.
4.50	116.
4.75	114.
5.00	113.
5.25	111.
5.50	110.
5.75	108.
6.00	107.
6.25	105.
6.50	103.
6.75	102.
7.00	100.
7.25	99.
7.50	97.
7.75	96.
8.00	94.
8.25	93.
8.50	91.
8.75	89.
9.00	88.
9.25	86.
9.50	85.
9.75	83.
10.00	82.
10.25	80.
10.50	79.
10.75	77.
11.00	75.
11.25	74.
11.50	72.
11.75	71.
12.00	69.
12.25	68.
12.50	66.
12.75	64.
13.00	63.
13.25	61.
13.50	60.
13.75	58.
14.00	57.
14.25	55.
14.50	54.
14.75	52.
15.00	50.
15.25	49.
15.50	47.
15.75	46.
16.00	44.
16.25	43.
16.50	41.
16.75	40.
17.00	38.
17.25	36.
17.50	35.
17.75	33.
18.00	32.
18.25	30.
18.50	29.
18.75	27.
19.00	25.
19.25	24.
19.50	22.
19.75	21.
20.00	19.
20.25	18.
20.50	16.
20.75	15.
21.00	13.
21.25	11.
21.50	10.
21.75	8.
22.00	7.
22.25	5.
22.50	4.
22.75	2.
23.00	1.

GRIP STRENGTH (POUNDS)
LABORATORY AND FIELD TEST VALUES

Lbs.	Pts.
50	60.
51	61.
52	62.
53	63.
54	65.
55	66.
56	67.
57	68.
58	69.
59	71.
60	72.
61	73.
62	74.
63	75.
64	77.
65	78.
66	79.
67	80.
68	81.
69	83.
70	84.
71	85.
72	86.
73	87.
74	89.
75	90.
76	91.
77	92.
78	93.
79	95.
80	96.
81	97.
82	98.
83	99.
84	101.
85	102.
86	103.
87	104.
88	105.
89	107.
90	108.
91	109.
92	110.
93	111.
94	113.
95	114.
96	115.
97	116.
98	117.
99	119.
100	120.

Lbs.	Pts.
101	121.
102	122.
103	123.
104	124.
105	126.
106	127.
107	128.
108	129.
109	130.
110	132.
111	133.
112	134.
113	135.
114	136.
115	138.
116	139.
117	140.
118	141.
119	142.
120	144.
121	145.
122	146.
123	147.
124	148.
125	150.
126	151.
127	152.
128	153.
129	154.
130	156.
131	157.
132	158.
133	159.
134	160.
135	162.
136	163.
137	164.
138	165.
139	166.
140	168.
141	169.
142	170.
143	171.
144	172.
145	174.
146	175.
147	176.
148	177.
149	178.
150	180.

PERCENT BODY FAT
FIELD TEST VALUES

%	Pts.
4.0	58.
4.5	58.
5.0	57.
5.5	56.
6.0	55.
6.5	54.
7.0	53.
7.5	52.
8.0	51.
8.5	50.
9.0	49.
9.5	48.
10.0	47.
10.5	46.
11.0	45.
11.5	44.
12.0	43.
12.5	43.
13.0	42.
13.5	41.
14.0	40.
14.5	39.
15.0	38.
15.5	37.
16.0	36.
16.5	35.
17.0	34.
17.5	33.
18.0	32.
18.5	31.
19.0	30.

%	Pts.
19.5	29.
20.0	28.
20.5	27.
21.0	27.
21.5	26.
22.0	25.
22.5	24.
23.0	23.
23.5	22.
24.0	21.
24.5	20.
25.0	19.
25.5	18.
26.0	17.
26.5	16.
27.0	15.
27.5	14.
28.0	13.
28.5	12.
29.0	11.
29.5	11.
30.0	10.
30.5	9.
31.0	8.
31.5	7.
32.0	6.
32.5	5.
33.0	4.
33.5	3.
34.0	2.
34.5	1.
35.0	0.

LEAN WEIGHT (POUNDS)
FIELD TEST VALUES

Lbs.	Pts.
90	132.
91	134.
92	135.
93	137.
94	138.
95	140.
96	141.
97	143.
98	144.
99	145.
100	147.
101	148.
102	150.
103	151.
104	153.
105	154.
106	156.
107	157.
108	159.
109	160.
110	162.
111	163.
112	165.
113	166.
114	168.
115	169.
116	170.
117	172.
118	173.
119	175.
120	176.
121	178.
122	179.
123	181.
124	182.
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174	256.
175	257.
176	259.
177	260.
178	262.
179	263.
180	265.
181	266.
182	267.
183	269.
184	270.
185	272.
186	273.
187	275.
188	276.
189	278.
190	279.

STEP TEST SCORES
FIELD TEST VALUES

(ml/kg/mm) Score	Pts.
20	73.
21	76.
22	80.
23	84.
24	87.
25	91.
26	95.
27	98.
28	102.
29	106.
30	109.
31	113.
32	116.
33	120.
34	124.
35	127.
36	131.
37	135.
38	138.
39	142.
40	146.
41	149.
42	153.
43	157.
44	160.
45	164.
46	167.
47	171.
48	175.
49	178.
50	182.
51	186.
52	189.
53	193.
54	197.
55	200.
56	204.
57	207.
58	211.
59	215.
60	218.

PUSH-UPS
FIELD TEST VALUES

Reps	Pts.	Reps	Pts.
0	0.	26	77.
1	3.	27	80.
2	6.	28	83.
3	9.	29	86.
4	12.	30	89.
5	15.	31	92.
6	18.	32	95.
7	21.	33	98.
8	24.	34	101.
9	27.	35	104.
10	30.	36	107.
11	33.	37	110.
12	36.	38	113.
13	38.	39	115.
14	41.	40	118.
15	44.	41	121.
16	47.	42	124.
17	50.	43	127.
18	53.	44	130.
19	56.	45	133.
20	59.	46	136.
21	62.	47	139.
22	65.	48	142.
23	68.	49	145.
24	71.	50	148.
25	74.		

SIT-UPS
FIELD TEST VALUES

Reps	Pts.	Reps	Pts.
0	0.	36	70.
1	2.	37	72.
2	4.	38	74.
3	6.	39	76.
4	8.	40	78.
5	10.	41	80.
6	12.	42	82.
7	14.	43	84.
8	16.	44	86.
9	18.	45	88.
10	20.	46	90.
11	21.	47	92.
12	23.	48	94.
13	25.	49	96.
14	27.	50	98.
15	29.	51	100.
16	31.	52	102.
17	33.	53	104.
18	35.	54	105.
19	37.	55	107.
20	39.	56	109.
21	41.	57	111.
22	43.	58	113.
23	45.	59	115.
24	47.	60	117.
25	49.	61	119.
26	51.	62	121.
27	53.	63	123.
28	55.	64	125.
29	57.	65	127.
30	59.	66	129.
31	61.	67	131.
32	62.	68	133.
33	64.	69	135.
34	66.	70	137.
35	68.		

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